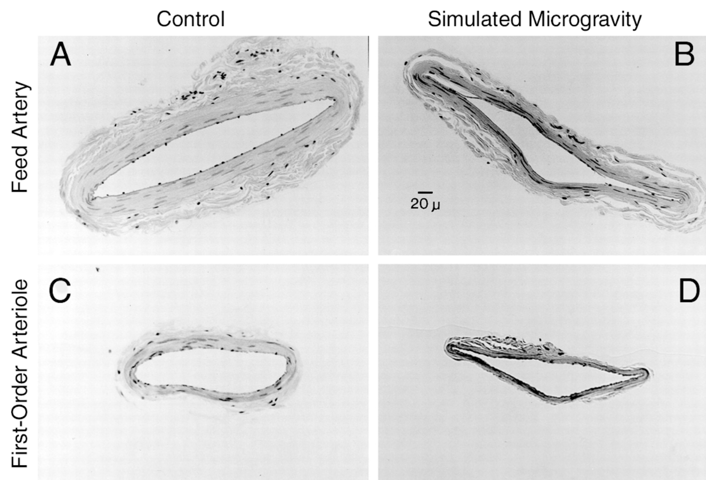
Understanding How Space Travel Affects Blood Vessels

Arterial Remodeling and Functional Adaptations Induced by Microgravity

Ever rise quickly from the couch to get something from the kitchen and suddenly feel dizzy? With a low heart rate and relaxed muscles, the cardiovascular system does not immediately provide the resistance necessary to keep enough blood going to your head. Gravity wins, at least for a short time, before your heart and blood vessels can respond to the sudden change in position and correct the situation.

Actually, the human cardiovascular system is quite well adapted to the constant gravitational force of the Earth. When standing, vessels in the legs constrict to prevent blood from collecting in the lower extremities. In the space environment, the usual head-to-foot blood pressure and tissue fluid gradients that exist during the upright posture on Earth are removed.



This figure shows feed arteries and first-order arterioles from control rats and from rats that have experienced simulated microgravity. After flight, the small blood vessels in hindlimb skeletal muscles that provide blood pressure resistance will be analyzed for their responses to chemical signals and pressure changes, and for changes in vessel structure and gene expression.

Earth Benefits and Applications

This experiment will contribute toward attaining a better understanding of how fundamental biological systems, such as the cardiovascular system, respond to the microgravity environment.The detailed study of the resulting vascular adaptations triggered by microgravity will yield essential information on the basic physiological responses of individual blood vessels involved in blood flow and pressure regulation. This information will also support the development of treatments or countermeasures to improve crew health and performance following their return to a gravitational environment.

The subsequent shift in fluids from the lower to the upper portions of the body triggers adaptations within the cardiovascular system to accommodate the new pressure and fluid gradients. In animal models that simulate microgravity, the vessels in the head become more robust while those in the lower limbs become thin and lax. Similar changes may also occur in humans during spaceflight and while these adaptations are appropriate for a microgravity environment, they can cause problems when the astronauts return to Earth or perhaps another planet. Astronauts often develop *orthostatic intolerance* which means they become dizzy or faint when standing upright.

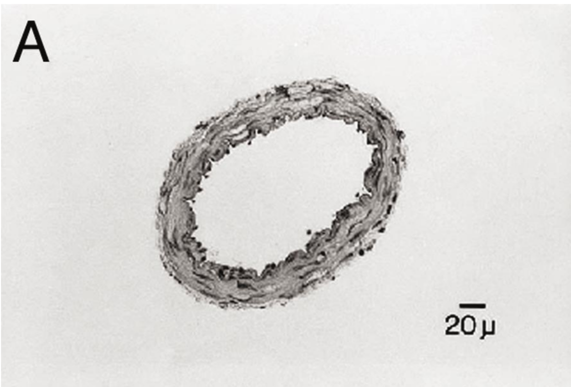
This dizziness can persist for a number of days making routine activities difficult. In an effort to understand the physiological details of these cardiovascular adaptations, Dr. Michael Delp at Texas A&M University, uses the rat as a model for his studies. For the experiment flown on STS–107, he will test the hypothesis that blood vessels in the rats' hindlimbs become thinner, weaker, and constrict less in response to pressure changes and to chemical signals when exposed to microgravity. In addition, he will test the hypothesis that arteries in the brain become thicker as a result of microgravity-induced fluid shifts toward the head.

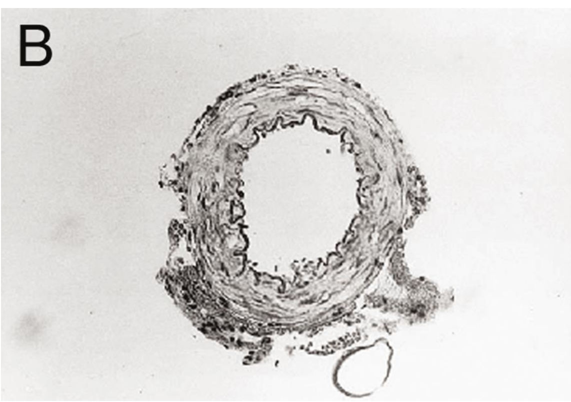
Principal Investigator: Dr. Michael Delp, Texas A&M University, College Station, TX
Project Scientist: Marilyn Vasques, NASA Ames Research Center, Mountain View, CA
Project Manager: Rudy Aquilina, NASA Ames Research Center, Mountain View, CA

Background Information

Science

From previous studies using models that simulate microgravity, it is now evident that the shift of fluid toward the head and the unloading of postural muscles together alter the mechanical forces exerted on arteries, the vessels responsible for regulating blood flow and arterial blood pressure. The purpose of the present study is to determine whether the fluid shifts and muscle unloading that occur in actual microgravity, similarly alter rodent arterial vessel structure and function.





A cross section of the basilar artery from the brain of a control rat (A) and a rat that experienced simulated microgravity (B).

This experiment will address the effects of microgravity on vascular smooth muscle and vascular endothelial cell function and structure in resistance arteries and arterioles isolated from skeletal muscle and the brain. Three groups of rats will be studied. These will consist of 8 rats flown in microgravity, 8 rats from a ground-based vivarium cage control group, and 8 rats from a ground-based AEM control group. Resistance arteries or arterioles will be isolated and used for physiology experiments, in gene expression studies, and structural analyses. This work will provide potentially important information about the mechanisms underlying the orthostatic intolerance experienced by astronauts returning to Earth.

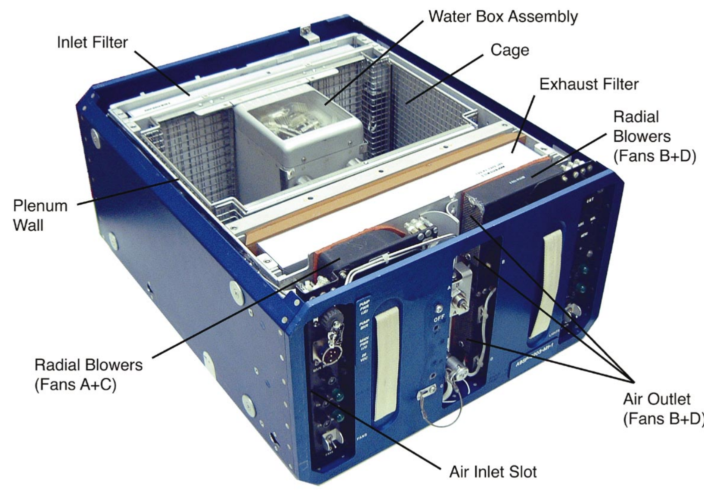
Science Discipline Supported

This experiment supports NASA's priorities for research aimed at understanding fundamental biological processes in which gravity is known to play a direct role and alleviating problems that may limit astronauts' ability to survive and/or function during prolonged spaceflight.

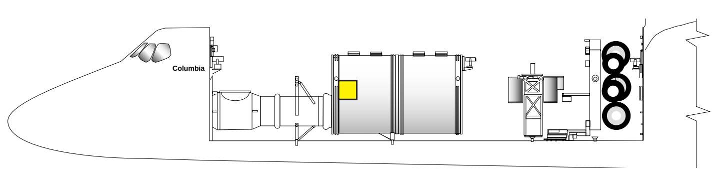
Hardware

The Animal Enclosure Module (AEM) is a rodent habitat that provides ventilation, continuous filtered air flow to control waste and odor, timed lighting, food in the form of foodbars attached to the side of the cage, and a water supply which can be refilled as required. Rodents in the cage compartment of the AEM are not accessible but can be viewed through the clear lexan cover. This also allows for viewing of water level remaining in the AEM water box.

The AEM has been designed for minimum crew interaction and the animals adapt very well to this virtually self-contained system. The only nominal operations required are a daily hardware check, a daily visual animal health check, and periodic water refills.



This experiment is part of the Fundamental Rodent Experiments Supporting Health (FRESH)-02 payload which consists of 13 rats housed in 3 AEMs. The animals, which will be shared among several different investigators, will experience microgravity for 16 days on board the Shuttle *Columbia*. The AEMs have been used successfully on many previous shuttle flights.



Approximate location of this payload aboard STS–107.

Picture credits. Delp (pages 1, 2), Ames Research Center (AEM).

KSC-2002-057a